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# UPDATE TO UFC 4-214-03 CENTRAL VEHICLE WASH FACILITIES

## LESSONS LEARNED AT CVWF'S SINCE 1990

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# UPDATE TO UFC 4-214-03 CENTRAL VEHICLE WASH FACILITIES: LESSONS LEARNED AT CVWF'S SINCE 1990

1. Purpose.

a. This Public Works Technical Bulletin (PWTB) summarizes lessons learned at existing Central Vehicle Wash Facilities (CVWFs). These lessons learned led to suggested updates to the planning and design guidance contained in Unified Facilities Criteria (UFC) 4-214-03 "Central Vehicle Wash Facilities." This PWTB includes the recommended updates.

b. All PWTBs are available electronically (in Adobe® Acrobat® portable document format [PDF]) through the World Wide Web (WWW) at the National Institute of Building Sciences' Whole Building Design Guide web page, which is accessible through URL:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

2. Applicability. This PWTB applies to all U.S. Army Corps of Engineers Districts and Divisions, and to all U.S. Army facilities engineering, public works, or environmental directorate activities that are involved in the planning, operation, design, or retrofit of CVWFs.

3. References.

a. UFC 4-214-03 "Central Vehicle Wash Facilities," 16 January 2004.

b. Technical Manual (TM) 5-814-9, "Central Vehicle Wash Facilities," February 1992.

c. Engineer Technical Letter (ETL) 1110-3-469, "Alternatives for Secondary Treatment at Central Vehicle Wash Facilities," 3 February 1995.

d. PWTB 420-49-31, "Lessons Learned at the Fort Sill Central Vehicle Wash Facilities," 6 September 1998.

4. Discussion.

a. In 2004, Army TM 5-814-9, "Central Vehicle Wash Facilities," was converted to UFC 4-214-03, without change. The publication contains planning and design guidance for centralized tactical vehicle washing facilities. The original TM was printed February 1992. Since that time, there have been significant lessons learned and further studies related to the guidance in the current UFC document. The U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC/CERL), formerly the Technical Center of Expertise for CVWFs, has concurred with several variations from the guidance during the designs of facilities post-1992. However, the information in the UFC has not been updated since the draft TM was written in 1990.

b. ETL 1110-3-469 was published following a study conducted by ERDC/CERL. The study evaluated three alternatives for secondary treatment of wash water recycled at CVWFs: intermittent sand filtration, lagoon, and constructed wetland. The ETL contains planning and design guidance for each of the three secondary treatment alternatives.

c. Innovative features were incorporated into the designs of two CVWFs constructed at Fort Sill, OK. Unfortunately, these attempts at improving on the standard design guidance in TM 5-814-9 were somewhat unsuccessful. PWTB 420-49-31 contains a discussion of the lessons learned from these two facilities.

d. Appendix A summarizes CVWF lessons learned and subsequent design guidance variations that have been allowed since TM 5-814-9 was written. The Appendix also contains recommendations for CVWF design features that are specific to washing Stryker armored vehicles.

5. Points of Contact (POCs). Headquarters, U.S. Army Corps of Engineers (HQUSACE) is the proponent for this document. The POC

at HQUSACE is Malcolm E. McLeod, CEMP-II, 202-761-0632, or e-mail: Malcolm.E.Mcleod@hq02.usace.army.mil.

Questions and/or comments regarding this subject should be directed to the technical POC:

U.S. Army Engineer Research and Development Center
Construction Engineering Research Laboratory
ATTN: CEERD-CN-E (Gary L. Gerdes)
2902 Newmark Drive
Champaign, IL 61822-1072
Tel. (217) 373-5831
FAX: (217) 373-3430
e-mail: Gary.L.Gerdes@usace.army.mil

FOR THE COMMANDER:

JAMES C. DALTON, P.E.
Chief, Engineering and Construction
Directorate of Civil Works

# Appendix A: Summary of Lessons Learned and Other Recommendations to Update UFC 4-214-03: Central Vehicle Wash Facilities

## Introduction

### Background

The Central Vehicle Wash Facility (CVWF) is a one of the most successful pollution prevention concepts developed and implemented by the U.S. Army Corps of Engineers (USACE). The recycle treatment systems used at the more than 25 existing facilities now save approximately 2.5 billion gallons of water every year. The first modern CVWFs were constructed in the early 1980s. Wash facilities are still being constructed in 2007, primarily as a result of Base Realignment and Closure installation realignments. New Brigade Combat Teams are being formed, and new wash facilities are being planned and constructed to accommodate their tactical vehicle washing needs. However, guidance for the planning and design of those facilities is somewhat dated.

Headquarters USACE published design guidance for CVWFs in 1992 in the form of Technical Manual (TM) 5-814-9, “Central Vehicle Wash Facilities.” That guidance was based on:

1. Research done by the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) between 1977 and 1987

2. Experience at a few facilities designed and constructed by Corps Districts in the mid-1980s

3. Washing requirements for the tactical vehicles being used in the mid-1980s.

In January 2004, TM 5-814-9 was replaced by the Unified Facilities Criteria (UFC) document: UFC 4-214-03, “Central Vehicle Wash Facilities.” The original TM was converted to the UFC document without change. The information in the UFC has not been updated since the TM was originally published. Several events have driven the need to update TM 5-814-9:

1. New families of tactical vehicles, particularly the Stryker variants, have replaced the older vehicles as part of a continuing program to modernize and transform the Army. Lessons learned from washing these vehicles at existing CVWFs need to be recorded.

2. Washing vehicles is now a means of preventing the spread of non-native invasive species (NIS), primarily by removing weed seed carried by the vehicles from training areas. Controlling NIS has become an important element of range management. New features specific to removing NIS matter from tactical vehicles are being tried at three CVWFs recently designed by Corps of Engineers District, Honolulu.

3. Some completed research led to Engineer Technical Letter (ETL) 1110-3-469, “Alternatives for Secondary Treatment at Central Vehicle Wash Facilities.” Many lessons learned regarding design details at existing CVWFs have been noted as well during the past two decades of CVWF usage. That body of information has not been formally recorded in Corps of Engineers planning and design guidance.

Because of the need to update CVWF design guidance, HQ USACE tasked ERDC/CERL to prepare this lessons learned PWTB. The intent of this bulletin is to create a reference document that may be used later to update UFC 4-214-03.

## HOW THIS REPORT IS ORGANIZED

This report lists changes and additions that are recommended for UFC 4-214-03. Each entry begins with a reference to the specific section or paragraph in the UFC document to be changed. Each entry may also include text explaining the reasoning behind the recommended change and, where appropriate, cites the locations of lessons learned. The report is organized in this way so that it may be used to complement, and in some cases supercede, the UFC during CVWF planning and design.

## RECOMMENDED ADDITIONS AND CHANGES TO UFC 4-214-03

### CHAPTER 1. INTRODUCTION

No changes.

### CHAPTER 2. CVWF DESIGN CONCEPT

Section 2-3. Wastewater treatment; *(b) Secondary treatment.*

Add a new paragraph between (1) and (2): *Constructed wetland treatment.* This secondary treatment system consists of one or more shallow basins that are covered by a growth of wetland plants, usually reeds or cattails. As water flows through the constructed wetland cell(s), the aquatic plants tend to act as a horizontal filter. Suspended solids and oil and grease particles attach to the plants and are removed from the recycle water. ETL 1110-3-469 “Alternatives for Secondary Treatment at Central Vehicle Wash Facilities” explains the constructed wetland option in greater detail.

Section 2-3. Wastewater treatment.

Add a new paragraph: *d. Limitations.* The CVWF recycle system described in this document is intended to treat wash water contaminated by suspended solids, some dissolved organics, and small amounts of oil and grease. The use of soaps, detergents, and solvents will adversely affect the quality of the recycle water. It is recommended that the use of these chemicals be prohibited at CVWFs.

### CHAPTER 3. MASTER PLANNING

Section 3-2 Siting; a. *Geography;* (4) *Transportation arteries*

After the sentence “The entrance and exit of the wash facility should be sited to avoid adverse effects on traffic both there and in the cantonment area.” add: The entrance and exit should be oriented such that washed vehicles exiting the facility do not drive over the same roadway traveled by unwashed vehicles.

Reasoning: Dirty vehicles approaching the CVWF from training areas drop a lot of soil on the roadway leading to the entrance. If clean vehicles are driven over the same roads, they will become dirty again, which defeats the purpose of washing them.

Section 3-2 Siting: *c. Geology.*

Add new paragraph: *(7) Unique conditions.* The planner and designer must determine if unique site conditions exist that will impact structure design or location, such as the soil gas situation described below.

Reasoning: Lesson learned at a CVWF in Texas. The soil at that site contained a significant amount of natural gas. The gas accumulated under the membrane liners of the basins, causing huge “bubbles” in the liner which eventually stretched to the surface of the basin. Vent pipes had to be installed under the liner to prevent the gas buildup.

Section 3-2 Siting; *d. Utilities; (1) Water; (b) Makeup water.*

Add this second paragraph: A study at Fort Carson determined that 5 percent of the annual water usage at the CVWF had to be replaced with make-up water. Usage at Fort Carson is about 200 million gallons per year, so about 10 million gallons of water were added. Fort Carson is in a semi-arid climate, where annual precipitation is about 15 inches. Surface evaporation in the area is about 30 inches. While losses at Fort Carson may be higher than at the majority of training installations, the requirement for 5 percent makeup water would be a reasonable “rule of thumb” for use by planners and designers.

Reasoning: Explained in added paragraph above.

## CHAPTER 4. STANDARD WASH FACILITY

### Section I. VEHICLE PREPARATION AREA

Section 4-2 Sizing; *a. Preparation area*

Add the following as the first paragraph of this section: It should be determined what the typical number of vehicles to enter the CVWF as a group will be. Often this will be the number of vehicles from a Company-sized unit. The preparation (or staging) area should be sized so that that group of vehicles will be able to line up behind the pre-wash and/or wash structures.

Add the following as the last paragraph of this section: When larger units (Battalion, Brigade) return from the training areas, there will often be vehicles lined up outside the CVWF waiting to be washed. These vehicles are usually parked on the roadside. The facility planner should include provisions to upgrade the sides of the entrance road(s) for vehicle staging, or provide another area for soldiers to park vehicles prior to entering the CVWF.

Reasoning: Vehicle staging along entrance/access roads has caused road shoulders to deteriorate, leading to erosion.

Section II. WASH STATION

Section 4-13. Interior wash equipment (optional)

Change section title to "Optional wash equipment." Designate existing first paragraph as *a) Low flow hoses for interior washing.*

Add new paragraph: *b) High pressure hoses.* At some installations it is necessary to provide a greater degree of soil removal in order to prevent the spread of non-native invasive species (NIS). The seeds or spores of these invasive plants are easily transferred in the dirt clinging to tactical vehicles. To achieve complete removal of these seeds and spores, it is necessary to provide additional washing capability in the form of high pressure hoses. These hoses should provide a spray with a maximum pressure of 800 psi at a flow of 3 to 4 gpm. If the use of higher pressure is desired, the facility planner or designer should obtain concurrence from the appropriate Tank-automotive and Armaments Command (TACOM) Program Managers for the specific vehicles being washed.

Reasoning: Stated in the new paragraph above.

Section III. SUPPORT FACILITIES

Section 4-16. Signage.

Add at end of the paragraph: Signs should be posted at all wash islands and at the control building prohibiting the use of detergents, soaps, and solvents.

Reasoning: A lesson learned at many facilities – soldiers have been observed using off-the-shelf detergents to wash vehicles. Soaps, detergents, and solvents interfere with the recycle treatment system. Emulsified oil and grease will pass through the treatment system and tend to accumulate in the recycle water. The organic compounds will add to the bio-chemical oxygen demand (BOD) loading on the treatment system, and may encourage biological growth within the system.

Add: Section 4-19. Drinking Water and Latrines. Drinking water must be provided for the soldiers using the facility at CVWFs. Normally, a drinking fountain with spigot for filling canteens is placed at the control building. Latrines for the soldiers using the facility must be provided. Potable water and latrines are normally located in the control building, but may be elsewhere in the facility.

Reasoning: Lessons learned at several installations. Installations usually require access to potable water and latrines where troops gather for several hours.

## CHAPTER 5. OPTIONAL PREWASH

### Section I. TYPES OF PREWASH

Section 5-1. Introduction.

Add new paragraphs: *c. Optional undercarriage spray.* The undercarriage of all tactical vehicles is difficult to clean, even when a prewash bath is available. Planners and designers should consider including an undercarriage spray station to clean the areas on the vehicle that cannot be reached by the water cannons, and are difficult to reach with hoses. Undercarriage sprays are a standard feature at U.S. Army wash facilities in Germany, and were in use at the Armor School wash facilities formerly at Fort Knox. An undercarriage sprayer generally consists of a header pipe fitted with numerous spray nozzles. The axis of the pipe is in line with the direction of vehicle movement. The length of the pipe should be appropriate for the average vehicle using the underspray. Vehicles may move back and forth over the spray pipe to get a more thorough cleaning. The pipe may be fixed, but pipes that pivot either automatically or manually will do a better job of cleaning. Undercarriage spray equipment is commercially available.

Reasoning: Lesson learned at Fort Knox and U.S. Army Europe installations that have undercarriage sprays, and at all existing Army facilities in the United States that do not.

Section 5-2. Bath prewash; *f. Water cannons; (1) Water pressure and flow rates.*

Delete: “The recommended water pressure is 100 psi (6.8 atmospheres) at the nozzles. The recommended nozzle flow rate is 80 gpm (300 liters per minute).” Replace with: “The recommended water pressure can vary between 80 and 100 psi (5.4

and 6.8 atmospheres). The flow rate should be 80 gpm (300 liters/min) at 100 psi.”

Reasoning: Lesson learned at Fort Polk. High flow/low pressure and low flow/high pressure are equally effective at removing large amounts of dirt from vehicles. The water cannons at Fort Polk originally had flows over 300 gpm at about 30 psi. When the high flow nozzles were replaced with nozzles having smaller orifices, the flow became 80 gpm at 100 psi, and was equally as effective. Lower flow is desirable because it allows the recycle treatment system to be smaller.

Section 5-2. Bath prewash; *f. Water cannons; (3) Nozzles.*

At end of paragraph add: Nozzles are subject to erosion and corrosion, and should be made of a hard, non-corroding, steel.

Reasoning: Lesson learned at Fort Polk. Nozzles made of the softer metal brass cracked and eroded quickly. The brass nozzles at Polk were replaced with nozzles made of stainless steel. Brass is also susceptible to theft.

Section 5-2. Bath prewash; *g. Cannon islands.*

Delete: “If the user requires, hose connections may be included in the island design for cleanup purposes.” Replace with “It is necessary to use washdown hoses to remove the sediment that accumulates in the bottom of the bath following a wash exercise. It is recommended that hose connections be included at each cannon island to allow efficient washdown of the bath bottom.”

Reasoning: Lesson learned at Fort Polk. The fixed water cannons do not work as well as hoses for cleaning up the bath bottom.

Section 5-2. Bath prewash; *h. Flexors.*

Add at the end of the paragraph: The first flexor at the entrance of a tracked vehicle lane should be 6 to 8 feet from the base of the entrance ramp. The space between the first flexor on each side of the land and the entrance ramp should be filled with concrete to a level even with the top of the first flexor. The space between the last flexors and the exit ramp should also be filled.

Reasoning: Lesson learned at Fort Polk. Drivers had difficulty driving over flexors placed immediately at the bottom of the entrance and exit ramps.

Section 5-2 Bath prewash; *h. Flexors; (2) Dual-purpose lanes.*

Delete the sentence “The flexors should be spaced 18 inches (45.7 centimeters) apart.” Replace with: “For large wheeled vehicles, the flexors should be spaced 18 inches apart. If smaller wheeled vehicles are to use the bath, flexors should be spaced 15 inches apart.”

Section 5-2 Bath prewash; *i. Entrance ramp.*

Delete: “The maximum allowable slope into the bath is 1:7 (14 percent).” Replace with: “The entrance ramp should have a maximum slope of 1:11 (9 percent).” Figures 5-1, 5-2, 5-6, 5-7, and 5-10 should be modified to show 1:11 slopes.

Reasoning: Lesson learned at Fort Polk, Fort Riley, and Fort Carson. The gentler slope is easier to traverse by drivers, and allows much better and quicker washing at the entrance water cannons.

Section 5-2 Bath prewash; *(k)Ramp slope.*

Delete this paragraph.

Section 5-2. Bath prewash; *m. Outlet control structure.*

Delete: “A valve or gate is located in the structure at the intersection with the transverse u-drain to allow wastewater to discharge into the structure.” Replace with: “A valve in line with the transverse U-drain is used to empty the bath. That valve should be a gate valve, or other non-obstructing valve, that will not easily catch vegetation that will cause blockage.”

Reasoning: Lesson learned at Fort Polk. The butterfly valve installed there routinely collected vines and other debris and required cleaning each time the bath was dumped.

Section 5-2. Bath prewash

Add new paragraph: *n. Fill water.* The water used to fill the bath does not need to have secondary treatment. It is recommended that water to fill the bath (and for the trench flushers) be pumped directly from the equalization basin. This design feature will significantly reduce the required area of sand filters as compared to using filtered water to fill the bath and flush the trenches.

Reasoning: Water used to fill the bath and flush trench drains does not need to be treated to the same level as water that is sprayed on soldiers and vehicles.

Section 5-5. Wastewater conveyances.

Add as first sentence of paragraph: Trench drains and piping carrying untreated wash water require steep slopes to maintain enough water velocity to keep soil and rocks moving.

Add after "… 5 fps (1.8 meters per second) velocity.": Two percent or steeper is recommended. At most sites it is advantageous to site the primary treatment basins as close to the wash structures as possible in order to minimize the length of steeply sloped piping, and thus minimize elevation drops between the wash structures and primary treatment.

Reasoning: Generally, minimizing the elevation change between structures will minimize the amount of earth moving during site preparation. This may not be true at sites having a significant amount of natural relief.

Section III. PRIMARY TREATMENT

Section 6-12. Number of basins.

Add new paragraph: *e. Triple cell configuration.* Installations with clayey soils in their training areas should consider a three-cell configuration of the primary basins. One of the three cells can be taken off line for extended periods of time to allow the sediment to dewater and dry during cleanout. Clayey soils dry very slowly. Even thin layers (4 inch depth) can take several weeks to months to dry enough to be easily removed from the basin. The three cell configuration would be designed so that any one of the cells could be taken off line and drained while the other two cells remained in service. The three-cell configuration would also be desirable at CVWFs with continuous usage.

Section 6-14. Sizing.

Add new paragraph: *d. Bottom configuration.* From the standpoints of treatment and maintenance, it is best to maximize the area of the sedimentation basin bottom. Shallow basins provide more efficient sedimentation. It is recommended that the wetted depth be 4 feet (including 1 foot of sediment, not including freeboard). A shallow basin can have a larger length to width ratio to increase treatment performance and still maintain an acceptable width that will allow cleanout vehicles to maneuver. A larger bottom will also allow decrease the average depth of the sediment, making in-situ drying more efficient. Finally, a shallow basin will have a shorter access ramp.

Section 6-19. Sediment removal.

Add as a second paragraph to this section: Sediment does not accumulate in an even layer across the bottom of the sedimentation basin. Instead, the basin acts as a soil particle classifier – sands and silt particles settle quickly and form a mound near the influent structure, while fine silt and clay particles settle very slowly and form a relatively even layer. At existing CVWFs, the fine silt and clay particle layer begins at about one-third the length, and gradually decreases in depth toward the effluent structure. As a general rule, about 50 to 60 percent of the sediment forms a mound in the first third of the basin.

Figures 6-1 and 6-2, page 6-5; and figures 6-3 and 6-4, page 6-6.

Change: The slope on the ramp accessing a primary treatment sedimentation basin should be changed from 1:6 to 1:11 (9 percent).

Reasoning: A lesson learned at existing CVWFs – slope of access ramps was too steep. Front loaders and other equipment had difficulty maintaining traction on steeper slopes. A shallower slope is needed to efficiently and safely clean out the sedimentation basins.

Section 6-19. Sediment removal.

Add as third paragraph to this section: Sediment removal will be the most resource-intensive maintenance operation at a CVWF. The water saturated clayey sediment is very difficult to handle when wet, and requires long periods of drying to make it suitable for removal to a disposal site. The designer and planner should carefully consider the design options that impact this operation.

Add new sub-paragraphs at end of section: *a. Design options.* The following options are listed in order of preference to a facility user.

*(1) Three-basin configuration.* Sediment is easiest to move after it has dried. The three-basin configuration allows the sediment to be left in place for extended periods of time to allow drying. During that time, the other two basins may remain in service to provide the maximum primary treatment. The dried sediment is then transferred once, from the basin to the disposal site. This is the most desirable option with respect to maintenance, but requires the highest construction cost.

*(2) Two-basin configuration.* The two-basin design is usable at facilities where one basin can be taken off line for long periods of time to allow the sediment to dry in place.

*(3) Two- or one-basin configuration with adjacent drying surface.* This option is desirable at locations where due to facility usage, a basin cannot be taken out of service for long periods of time, and funding is not available to construct a third basin. The basin and adjacent drying surface can be configured in three ways.

*(a) Drying area placed at elevation of the basin bottom.* The sedimentation basin can be designed so that a vertical section of wall can be temporarily removed after the basin has been drained. When the wall section is removed, the sediment can be easily pushed from the basin bottom, through the opening in the wall, and onto a drying surface adjacent to the basin bottom. The drying surface should be sloped away from the basin bottom to prevent backflow – about 1% slope. The advantage of this option is that the sediment does not have to be loaded into trucks and then unloaded at a drying area. This alternative is being used successfully at the Yakima Training Center CVWF, and is recommended at all locations where site conditions permit its use.

*(b) Drying area adjacent to the basins.* The sedimentation basin and drying area can be constructed so that a front-loader can dump over the wall of the basin and onto an adjacent drying surface. The wall of the basin must either be short enough for this to happen, or a portion of the wall must be removable. Sediment removal will not be as efficient as in option (a) because the sediment will have to moved one bucketful at a time. This option does eliminate the need for transfer trucks.

*(c) Drying area near the basins.* This option requires the sediment to be transferred by truck from the bottom of the basin to a drying surface nearby. This is the least efficient option. However, only one drying surface will be necessary. It will be difficult to configure the structures in options (a) and (b) in such a way that only one drying surface is needed.

*(d) Drying area design.* The drying area should be sized so that the depth of the sediment removed from the sedimentation basin is a maximum of 4 inches. The area should be a concrete surface able to support the weight of a front loader and loaded dump truck. The area should be sloped (maximum 1 percent) toward a drain on the perimeter of the area. Sediment in the drying area should be confined by a perimeter curb or subwall, at least 6 inches in height. There should be a rollover curb to give access to service vehicles.

Drying time can be significantly shortened if the drying area is constructed with an underdrain system similar to that used for sludge drying at a wastewater treatment plant.

Section 6-23. Other considerations.

Add at end of paragraph: Do not install floating covers on basins to control evaporation. The covers prevent adequate aeration, and the basin can become septic when not in use.

Reasoning: Lesson learned at Fort Irwin.

Section IV. SECONDARY TREATMENT

Section 6-24. Onsite secondary treatment.

Add as second paragraph to this section: Designers and planners using UFC 4-214-03 should also refer to Engineer Technical Letter 1110-3-469 “Alternatives for Secondary Treatment at Central Vehicle Wash Facilities.” This document contains further information regarding intermittent sand filter and lagoon treatment, as well as design guidance for a third treatment alternative, constructed wetlands.

Section 6-26 Intermittent sand filtration system;
*a. Equalization basin; (6) Sediment removal.*

Change: The ramp to access the bottom of the equalization basin should have a 1:11 (9 percent) slope.

Reasoning: Lesson learned during the cleanout of existing sedimentation basins.

Section 6-26 Intermittent sand filtration system;
*c. Intermittent sand filters; (4) Distribution system.*

Delete paragraph and replace with: Water may be distributed on the surface of the filter using any method that does not erode the surface of the sand. One design configuration that has been successful at several CVWFs uses perforated plastic pipes placed on the surface of the sand in a grid pattern (fig. 6-13). The drilled orifices in the pipes should be at least 0.16 inch (4 millimeters) in diameter or larger to prevent the openings from clogging. The pipes must be sized to distribute the water as evenly as possible. The filter distribution piping should be easy to disassemble and remove to allow maintenance to the filter surface.

Delete: Figures 6-14 and 6-15.

Reasoning: Lesson learned at Fort Lewis – distribution boxes configured as shown in the figures tend to cause erosion of the sand filter surface. The distribution grid shown in Figure 6-13 is the preferred design configuration.

Section 6-26. Intermittent sand filtration systems;
*c. Intermittent sand filters; (7) Filter maintenance considerations*

Add new paragraphs: *(e)* Algal growth on the surface of the sand filters has become a maintenance and operational problem at several existing CVWFs. The algal growth problem is most prevalent at locations that have clayey soils, and/or at installations that have poorly drained maneuver areas. When clayey soil is washed from vehicles, the clay particles carried by the wash water tend to pass through pre-treatment and are deposited on the surface of the sand filters. When a layer of clay particles accumulate on the filter surface, infiltration slows to a point where water will pond and support the growth of algae on the filter surface. Algae are introduced into the recycle system when algae laden soil is carried into the wash facility from swampy training areas. The algae organisms initially attach to the sand particles of the filters, and contribute to filter plugging. After plugging begins, growth of suspended algae will appear in the water standing on the filter surface, and then further decrease the rate of infiltration.

The addition of a disinfectant has been proven to successfully control algae in experiments at the Aberdeen Proving Ground wash facility, and at the Fort Sill wash facilities. Disinfectant can be added manually by merely mixing dry or liquid swimming pool chemical into the wet well of the filter dosing pumps. An alternative is to provide an automatic chemical feed to the filter dose water. Beneficial microorganisms growing within the sand filter provide a minimal degree of biological treatment. Therefore, it is better to periodically add disinfectant rather than to continuously feed disinfectant upstream of the filters. An experimental dose of 10 ppm chlorine was used successfully at Aberdeen Proving Ground; this would be a good starting dosage. Because every location is unique with regard to algal loading, the appropriate dosage may be higher or lower. Operational experience will dictate what the appropriate dosage will be at a given site. Other methods of disinfection that do not leave long-term residuals, including ozonation and ultraviolet (UV), could be just as effective.

Reasoning: Lesson learned at Fort Benning, Fort Hood, and Aberdeen Proving Ground where algae contributes to filter plugging.

Section 6-26. Intermittent sand filtration systems;
*c. Intermittent sand filters; (3) Sizing.*

Add new paragraph: *(f) Reuse of unfiltered water.* The surface area of the filters can be minimized if water from the equalization is used to fill the bathes and flush trench drains.

Reasoning: Water to fill the bath or flush trench drains need not be filtered. The amount of recycled water that does not have to be filtered is significant.

Section 6-27. Lagoon system *b. Components (3) Liner*

Replace existing paragraph, and replace with: A liner is needed to prevent exfiltration of partially treated water to ground water, and to prevent erosion at the water’s edge. The liner material must be resistant to petroleum products and to ultraviolet (UV) light. Sediment that accumulates in the lagoon will need to be cleaned out periodically. It is recommended that the bottom of the lagoon be able to support service vehicles, and that a concrete ramp be included in the design to allow access. The recommended slope on the ramp is 1:11 (9 percent). The lagoon must have one or more ladder-type structures so people and animals can climb out after accidentally falling in.

Reasoning: Lesson learned at Fort Polk.

## Section VI. OTHER TREATMENT SYSTEM COMPONENTS

Section 6-35. Water source

Add paragraph: *d. Rule of thumb.* A study at Fort Carson determined that 5 percent of the annual water usage at the CVWF had to be replaced with make-up water. Usage at Fort Carson is about 200 million gallons per year, so about 10 million gallons of water were added. Fort Carson is in a semi-arid climate, where annual precipitation is about 15 inches. Surface evaporation in the area is about 30 inches. While losses at Fort Carson may be higher than at the majority of training installations, the requirement for 5 percent make-up water would be a reasonable “rule of thumb” for use by planners and designers.

Reasoning: Explained in paragraph above.

Section 6-35. Water source

Add new paragraph: *d. Usage monitoring.* It is recommended for good management practice that flow meters be installed to measure recycle water usage and make-up water added to the CVWF system.

Reasoning: Usage information is valuable to installation personnel in the Maintenance Division and the Environmental Division or Directorate.

Section 6-36. Piping.

Add after the text “… to prevent solids deposition.”: Pipes and channels carrying untreated wash water must have a slope of at least 2.0 percent.

Add after the text “… whenever possible for ease of maintenance”: Trench flushing is normally installed to prevent blockage by mud and debris in the wash station trench drains. All trenches must have removable grating to allow easy removal of blockages.

Reasoning: Lesson learned at Fort Carson and Fort Riley.

**CHAPTER 7. OTHER DESIGN CONSIDERATIONS**

Insert new section 7-3 (renumber existing sections 7-3, 7-4, and 7-5): 7-3. Pump house. Normally all pumping is consolidated in one or two pump houses with wet wells. These pump houses must be designed to allow the removal of pumps and pump motors for repair or replacement. Pump houses should have a means to remove water from the wet wells to allow access to the pump intakes, impellers, etc. Control panels in the pump houses should have a manual override switch for each pump. Pump houses should have emergency lighting. To document water reuse, install meters to measure the amount of water that is treated and recycled, and the amount of make-up water that is added to the system.

Section 7-2. Piping.

Add at end of the paragraph: All motorized valves should have the capability for manual operation. Actuator motors for valves often require maintenance or repair. Install actuator motors in manholes or above grade for easy access.

Reasoning: Lesson learned at Fort Polk.

APPENDIX A DESIGN EXAMPLE

Section A-3 Engineering and design; *a. Bath design*

Replace *(3) Entrance ramp* and *(4) Exit ramp* with: *(3) Entrance and exit ramps.* The maximum slope on the entrance and exit ramps of 1:11 (9 percent) will be used. With this slope, and a freeboard of 1 foot, the horizontal length of each ramp is 49.5 feet (15.1 meters), as shown on Figure A-3. The wetted length of the ramp at maximum depth of 3.5 feet (1.1 meter) is 38.5 feet (11.7 meters) as shown on Figure A-6. Flow and volume calculations should be changed to reflect this modification.

*Figure A-3. Bath Design*

Changes: Show slope of entrance ramp as 1:11. Show length of both entrance and exit ramps as 49.5 FT (15.1 M).

*Figure A-6. Cross section of the bath.*

Changes: Show entrance slope as 1:11. Show length of wetted ramp as 38.5 FT (11.7 M). In the Cross Section Area equation, replace 24.5 with 38.5. Show Cross Section Area as 310 $FT^2$ (28.8 $M^2$).

Section A-3. Engineering and design; *d. Sizing the treatment system; (6) Sediment basin design; Figure A-7. Water volume configuration: (a) plan view and (b) cross section.*

Change: Show slope on the ramp to be 1:11.

*Figure A-7. Water volume configuration: (a) plan view and (b) cross section.*

*Change slope shown in drawing (b) from 1:6 to 1:11.*

*Change the horizontal length of the ramp shown in (b) from 48 FT (14.4 M) to 102 FT (30.5 M). The depth* $D_s$ *should be shown as 1.25 FT (0.4 M)*